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L1	(programmable adj1 element) or antifuse	2948	L1

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L10: Entry 2 of 4 File: USPT Jul 23, 2002

DOCUMENT-IDENTIFIER: US 6424161 B1
** See image for Certificate of Correction **
TITLE: Apparatus and method for testing fuses

Brief Summary Text (9):
Antifuses are typically fabricated with a structure similar to that of a capacitor, such that two conductive electrical terminals are separated by a dielectric layer. In the unprogrammed state, in which the antifuse is fabricated, there is a high resistance between the terminals, while in the programmed state, there is low resistance. To program an antifuse, a large programming voltage is applied across the antifuse terminals, breaking down the interposed dielectric and forming a conductive link between the antifuse terminals.

CLAIMS:

1. A method for testing a programmed fuse in an integrated circuit, the method comprising: selecting a control resistor fabricated to have a known resistance; measuring a testing time for the control resistor having the known resistance; measuring a testing time for the programmed fuse having an unknown resistance; and comparing the testing time for the programmed fuse against the testing time for the control resistor and determining the resistance of the programmed fuse therefrom. applying a voltage to the control resistor; and measuring a time period for the voltage to decay to a decayed voltage less than or equal to a reference voltage.

2. The method of claim 1, further comprising selecting a resistance value of the control resistor from a plurality of known resistances according to a design parameter.

4. The method of claim 1, wherein measuring the testing time for the control resistor further comprises: selecting the control resistor from a plurality of resistors having known resistances; initializing a reference voltage in a testing circuit; applying a pre-charge voltage across the control resistor; allowing the pre-charge voltage to decay; determining a first time at which the pre-charge voltage has decayed to a value less than the reference voltage in the testing circuit; adjusting the reference voltage in the testing circuit to obtain an updated reference voltage; applying the pre-charge voltage across the control resistor; allowing the pre-charge voltage to decay; determining a second time at which the pre-charge voltage has decayed to a value less than the reference voltage in the testing circuit; repeating adjusting through determining a second time if the second time is less than the first time; and selecting the first time as the testing time for the control resistor.

5. The method of claim 1, wherein measuring the testing time for the control resistor further comprises: selecting the control resistor from a plurality of resistors having known resistances; initializing a reference voltage in a testing circuit; applying a voltage across a control resistor; causing the voltage across the control resistor to charge; determining a first time at which the voltage across the control resistor has increased to a value greater than the reference voltage in the testing circuit; adjusting the reference voltage in the testing circuit to obtain an updated reference voltage; applying a voltage across the

control resistor; causing the voltage across the control resistor to charge; determining a second time at which the voltage across the control resistor has increased to a value greater than the reference voltage in the testing circuit; repeating adjusting through determining a second time if the second time is less than the first time; and selecting the first time as the testing time for the control resistor.

15. The method according to claim 14 wherein selecting the control resistor further includes selectively connecting at least two resistors having known resistances to produce a desired resistance value for the control resistor.

16. A method for testing a programmed fuse in an integrated circuit, comprising: selecting a control resistor having a known resistance; selecting a reference voltage; applying a test voltage across the control resistor; comparing the test voltage across the control resistor to the reference voltage; measuring a test time when the test voltage matches the reference voltage; selecting a programmed fuse having an unknown resistance; applying the test voltage across the programmed fuse; comparing the test voltage across the programmed fuse to the reference voltage; measuring a fuse time when the test voltage matches the reference voltage; comparing the test time to the fuse time to determine if the fuse was programmed correctly.

19. A method for testing a programmed fuse in an integrated circuit, the method comprising: selecting a control resistor on the integrated circuit which has a known resistance; measuring a testing time for the control resistor having the known resistance; measuring a testing time for the programmed fuse having an unknown resistance; and comparing the testing time for the programmed fuse against the testing time for the control resistor to determine if the programmed fuse was properly programmed.

20. A method for testing a programmed fuse in an integrated circuit, the method comprising: selecting a control resistor to have a selectable known resistance; selecting a resistance value for the control resistor; measuring a testing time for the control resistor; measuring a testing time for the programmed fuse having an unknown resistance; and comparing the testing time for the programmed fuse against the testing time for the control resistor to determine the resistance of the programmed fuse to determine if the programmed fuse was properly programmed.

22. A method for testing programmed fuses in an integrated circuit, comprising: selecting a control resistor onto the integrated circuit fabricated to have a known resistance; measuring a control testing time for the control resistor; selecting a first programmed fuse having an unknown resistance; measuring a first testing time for the first programmed fuse; comparing the testing time for the programmed fuse against the testing time for the control resistor to determine the resistance of the first programmed fuse; changing the control testing time to a changed control testing time; selecting a second programmed fuse; measuring a second testing time for the second programmed fuse; and comparing the second testing time for the second programmed fuse to the changed control testing time to determine the resistance of the second programmed fuse.

23. A method for testing the state of a programmed anti-fuse in an integrated circuit, the method comprising: fabricating a control resistor on the integrated circuit to have a plurality of selectable resistance values; selecting a known resistance value for the control resistor from the plurality of selectable resistance values; measuring a decay time for the control resistor to produce a known decay time corresponding to the known resistance value; measuring a decay time for the programmed anti-fuse having an unknown resistance value; and comparing the decay time for the programmed anti-fuse to the known decay time to determine the resistance value of the programmed anti-fuse.

24. A method for testing a programmed anti-fuse in an integrated circuit, the method comprising: fabricating a control resistor on the integrated circuit to have a plurality of selectable resistance values; selecting a known resistance value for the control resistor from the plurality of selectable resistance values; applying a pre-charge voltage across the control resistor; comparing a decay voltage for the control resistor to a reference voltage to produce a known decay time corresponding to the known resistance value; applying the pre-charge voltage across the programmed anti-fuse; comparing a decay voltage for the programmed anti-fuse to the reference voltage to determine an anti-fuse decay time to for the programmed anti-fuse; and comparing the known decay time to the anti-fuse decay time to determine if the anti-fuse was properly programmed.

25. A method for testing a programmed anti-fuse in an integrated circuit, the method comprising: fabricating a control resistor on the integrated circuit to have a plurality of selectable resistance values; selecting a known resistance value for the control resistor from the plurality of selectable resistance values; applying a pre-charge voltage across the control resistor; comparing a decay voltage for the control resistor to a reference voltage; measuring the time it takes for the decay voltage to match the reference voltage and producing therefrom a decay time for the control resistor; adjusting the reference voltage to produce an adjusted reference voltage; applying the pre-charge voltage across the control resistor; comparing the decay voltage for the control resistor to the adjusted reference voltage; measuring the time it takes for the decay voltage to match the adjusted reference voltage and producing therefrom a new decay time for the control resistor; applying the pre-charge voltage across a programmed anti-fuse; comparing a decay voltage for the programmed anti-fuse to the adjusted reference voltage; measuring the time it takes for the decay voltage to match the adjusted reference voltage to determine if the programmed anti-fuse was properly programmed.

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US006424161B2

(12) **United States Patent**
Damon et al.

(10) **Patent No.: US 6,424,161 B2**
(45) **Date of Patent: *Jul. 23, 2002**

(54) **APPARATUS AND METHOD FOR TESTING FUSES**

(75) Inventors: **Tim Damon**, Meridian; **Phillip E. Byrd**, Boise, both of ID (US)

(73) Assignee: **Micron Technology, Inc.**, Boise, ID (US)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/146,688**

(22) Filed: **Sep. 3, 1998**

(51) **Int. Cl.**[7] **G01R 31/02**; G01R 27/26; H01H 31/02

(52) **U.S. Cl.** **324/550**; 324/537; 324/677

(58) **Field of Search** 324/550, 537, 324/711, 677

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(57) **ABSTRACT**

A voltage is applied across a control resistor, and the voltage is caused to decay. The decay is monitored by a testing circuit such as a comparator. When the voltage across the control resistor has decayed to a value less than or equal to a reference voltage in the comparator, a switch time period is established. Fuses in a memory device are tested against the established switch time period. The fuses are tested in a similar fashion: a voltage is applied across the fuse being tested, and the voltage is caused to decay. The comparator monitors the decay of the voltage across the fuse. If the resistance value of a fuse being tested is within specification, the comparator changes its state at a time equal to or less than the switch time period established for the control resistor. Testing time for fuses can further be minimized by having an external access to the reference in the comparator. In establishing the switch time period by applying a voltage across the control resistor, the voltage of the reference in the comparator is adjusted to establish quicker switch time periods against which fuses are tested. In this manner, testing time is minimized.

25 Claims, 7 Drawing Sheets